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CONDUCTIVE PAINTS MADE FROM NICKEL-PLATED GLASS MICROSPHERES

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It was found that modification of the surface of nickel-plated hollow glass microspheres with N-oxide-Cl-alkyldimethylamine causes overcharging of their surface and as a result improves wetting of particles of the solid phase with acrylic latex water-emulsion paint. The conductive paint coatings are characterized by high electrical conductivity. The paint developed can be used to protect people and equipment from electromagnetic radiation.

Conductive paint, similar to ordinary pigmented paint systems, is a suspension of a solid in a binder. Carbon black, graphite, industrial carbon, metal powders (silver, nickel, copper, etc.), and plated particles — core pigments (French patent application No. 2621328) are usually used as conductive fillers in paints [1, 2]. Thermoplastic resins (epoxy, phenol-formaldehyde, polyurethane, acrylic, organosilicon) or water-emulsion latex dispersions are used as film-forming binders.

Hollow glass microspheres coated with a layer of metal could be of special interest for fabricating conductive materials [3]. They do not settle in the polymer binder; they reduce the threshold concentration of filler at which the polymer binder acquires conductive properties; they significantly reduce the cost of fillers made from precious metals. In fabricating composite materials, it is necessary to take into consideration not only the nature of the filler and polymer but also their reaction on the interface, since the physicochemical properties and quality of filled materials are determined by adsorption of the polymer on the surface of the solid phase [4].

We investigated the possibility of creating conductive paints based on nickel-plated glass microspheres for applying coatings on different surfaces.

An acrylic latex-based water-emulsion paint was used as the binder and nickel-plated hollow glass microspheres (NHGM) with a bulk density of $0.5 - 0.7 \text{ g/cm}^3$ were used as the conductive filler [3].

The physicochemical indexes of these conductive paints and the coatings made from them were determined by standard methods (viscosity according to GOST 8420–74, drying time according to GOST 19007–73, hardness with the

TML pendulum instrument according to GOST 5233–89, and adhesion and compatibility with the painted surface according to GOST 15140–78 and GOST 29318–22, respectively).

The liquid compositions were prepared by mixing $5 - 20\%^2$ NHGS with $80 - 95\%$ binder. The finished paints were applied by pouring on wood, concrete, and brick. The viscosity of the paint according to a VZ-4 viscometer at $20 \pm 2^\circ\text{C}$ was 80 sec and the drying time of the coatings at room temperature was $2 - 2.5 \text{ h}$.

The electric resistance of the coatings was measured with a combined ShCh-4300 instrument. The resistivity of the coatings was calculated with the equation:

$$\rho_v = \frac{Rh\tau}{l},$$

where ρ_v is the resistivity, $\Omega \cdot \text{cm}$; R is the overall resistance of the coating, Ω ; h is the width of the coating, cm ; τ is the thickness of the coating, cm ; l is the distance between electrodes, cm .

The thickness of the conductive coating was measured with a MT-41NTs magnetic thickness gage.

The following parameters of experimental aqueous 0.05% solutions were measured on a Zetaphorometer IV microelectrophorometer (France): viscosity, dielectric constant, electrophoretic mobility of particles. The ξ potential was calculated with the Smolukhovsky equation:

$$\xi = \frac{4\pi\mu\eta}{\epsilon},$$

where μ is the electrophoretic mobility of the particles; η is the viscosity; ϵ is the dielectric constant.

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² Here and below: mass content.

The study of the microstructure of the coatings was conducted on a Cam-Scan 4 scanning electron microscope (England).

The studies showed that the surface of the NHGS was poorly wet with the binder, probably because of insufficient adsorption of the polymer on the surface of the filler. It was found that the surface of the NHGS and the binder particles were negatively charged (ξ potential equal to -5.28 and -10.68 mV, respectively). Since the surface of particles of the solid phase was negatively charged, it repulsed the negatively charged binder particles, which resulted in poor wetting of the filler by the polymer.

The charge of the particles was neutralized or completely recharged as a result of modification of the particles of solid phase with surfactants [5]. In reacting with the fillers, the SF affected adsorption of the polymer and consequently the properties of the composition [6].

The surface of the NHGS was modified with an aqueous solution of N-oxide-Cl-alkyldimethylamine with a ξ potential of 5.71 mV. A sample of NHGS weighing 0.2 g was placed in 10 ml of an aqueous solution of the SF of fixed concentration and stirred for 2 h (time of establishment of adsorption equilibrium), then the solution was separated from the residue by filtration and the ξ potential of the particles in the residue was determined.

It was found that the surface was recharged as a result of modifying the surface of NHGS with SF — all particles in the residue obtained were positively charged, and their ξ potential was equal to 5.52 mV.

The modified NHGS were satisfactorily wet and uniformly distributed in the polymer binder. This was because the positively charged particles of filler attracted the particles of the opposite pole, and multilayer structures with uniform distribution of the filler in the latex binder formed.

The compositions obtained are compatible with painted surfaces (wood, concrete, and brick) and the coatings applied on them adhere satisfactorily to these surfaces. The hardness of the coatings with an M-3 pendulum instrument was equal to 0.1 arb. unit.

The concentration of filler (see Table 1) is an important factor that affects the resistance of the coatings made with conductive paints.

TABLE 1

Composition	Mass ratio of components, %		Volume resistivity of paint coatings, $\Omega \cdot \text{cm}$
	binder	filler	
1	95	5	6.3
2	90	10	2.5
3	85	15	$8 \cdot 10^{-2}$
4	80	20	$5 \cdot 10^{-2}$

The volume resistivity of the coatings decreased with an increase in the concentration of filler. The coatings were characterized by low volume resistivity at a $15 - 20\%$ filler content (compositions 3, 4). A further increase in the filler content above 20% caused the coatings to crack. The microspheres were uniformly distributed in the latex binder in a coating of the optimum composition. A latex film covered the surface of the NHGS, and peeling of the film was not observed.

Modification of the surface of NHGS with N-oxide-Cl-alkyldimethylamine thus causes recharging of the surface of the microspheres and as a result improves wetting of the particles by the polymer. The coatings based on the conductive paint developed are characterized by high conductivity. The paint can be used for protecting people and equipment from electromagnetic radiation.

REFERENCES

1. V. E. Gul' and L. Z. Shenfil', *Conductive Polymer Composites* [in Russian], Khimiya, Moscow (1984).
2. A. A. Berlin (ed.), *Carbon Fibres and Carbon Composites* [Russian translation], Mir, Moscow (1988).
3. E. V. Shinkareva and A. M. Safonova, "Deposition of metal coatings by chemical reduction of nickel on glass microspheres," *Steklo Keram.*, No. 8, 27 – 28 (2003).
4. N. V. Baranova, "Adsorption of epoxy resin on nickel-plated glass microspheres," *Khim. Khim. Tekhnol.*, **47**(9), 111 – 113 (2004).
5. I. V. Petryanov-Sokolov, *Colloid Chemistry and Progress in Science* [in Russian], Khimiya, Moscow (1988).
6. S. N. Tolstaya and S. A. Shabanova, *Use of Surfactants in the Paint and Varnish Industry* [in Russian], Khimiya, Moscow (1976).